Q No. 7.5:-

$P_b = 7\%$ 48.88

$G_m = 2.24$ $G_b = 1.02$ $T_{R\&B} = 120^\circ F$ $(49^\circ C)$

$P = 50$ @ $77^\circ F$ $(25^\circ C)$ $G_g = 2.61$ $|E^*| = ??$ $T = 74^\circ F$ $(23.33^\circ C)$

$t = 0.02$ sec

FROM NOMOGRAPH:

@ $t = 0.02$, temp. diff $= 25.5^\circ C$

PI = ??

$$A = \frac{\log(50) - \log(80)}{25 - 49} = 0.0501$$

$$PI = \frac{20 - 500A}{1 + 50A} = 1.441$$

Stiffness modulus of bitumen $= 2.0 \times 10^7 \ N/m^2$

$V_b = 100 P_b G_m / G_b = (100 \times 0.07 \times 2.24)/1.02 = 15.37$

$V_g = (1 - P_b)\frac{G_m}{G_g} \times 100 = (1 - 0.07) \times \frac{2.24}{2.61} \times 100 = 79.82$

@ stiffness mod. of bit. $= 2 \times 10^7 \ N/m^2$

$V_b = 15.37\%$ & $V_g = 79.82\%$

stiffness modulus of mix $= 2 \times 10^3 \ N/m^2$

From eqn/s :-

$$\beta_1 = 10.82 - \frac{1.342(100 - V_g)}{V_g + V_b} = 10.82 - \frac{1.342(100 - 79.82)}{(15.37 + 79.82)} = 10.53$$

$$\beta_2 = 8 + 0.00568 V_g + 0.000235 V_g^2 = 8.138$$

$$\beta_3 = 0.6 \log\left(\frac{1.37 V_b^2 - 1}{1.33 V_b - 1}\right) = 0.732$$

$$\beta_4 = 0.7582(\beta_1 - \beta_2) = 1.818$$

$S_b = 2\times10^8$ N/m² ⇒ for 5×10^6 N/m² < S_b < 10^9 N/m²

$$\log S_m = \frac{\beta_4+\beta_3}{2}(\log S_b - 8) + \frac{\beta_4-\beta_3}{2}|\log S_b - 8| + \beta_2$$

$$= \frac{0.597 + 1.152}{2}(\log 10^8 - 8) + \frac{0.547 - 1.152}{2}|\log 10^8 - 8| + 9.814$$

$$= (0.852)(0) + 0 + 9.814$$

$$S_m = \exp(9.814)$$

$$= 6.52\times10^9 \text{ N/m}^2$$

$$= (0.852)(-0.699) + (-0.305)|-0.699| + 9.814$$

$$\log S_m = 9.30236$$

$$S_m = 10^{(9.30236)}$$

$$S_m = 2.006\times10^9 \text{ N/m}^2$$

$$S_m = 1.0\times10^9 \text{ N/m}^2$$

Both must be equal values.

Quiz on 12.

→ Mechanistic approach:

Qno. 7.6:-

$P_{200} = 5\%$ Penetration of 75 at 77°F

$|E^*| = ?$ @ 74°F $f = 8$ Hz

Data from Qno. 7.5:-

$P_b = 7\%$ $G_m = 2.24$ $G_b = 1.02$ Temp = 120°F (49°C)

$G_g = 2.61$ $\Rightarrow$ $V_b = 15.37\%$ $V_g = 79.82\%$ $V_a = 4.81\%$

Eqn. 7.28 $\Rightarrow$ $\lambda = 29508.2 (P_{77F})^{-2.1939}$

$= 29508.2 (75)^{-2.1939}$

$\lambda = 2.0849 \times 10^6$ poise

Using eqn. 7.29:

$\beta_5 = 1.3 + 0.49825 \log f$

$= 1.3 + 0.49825 \log(8)$

$\beta_5 = 1.75$

$\beta_4 = 0.483\, V_b = 0.483 \left(\frac{15.37}{7.424}\right) = 3.381$

$\beta_3 = 0.553833 + 0.028829 (5 \times 8^{-0.4703}) - 0.03476 (4.81) + 0.070377 (2.0849 \times 8) + 0.931757 \times 8^{-0.02774}$

$= 0.553833 + 0.1011587 - 0.1671956 + 0.146722 + 0.8795$

$\beta_3 = 1.514048685$

$\beta_2 = \beta_4^{1/2}\, T^{\beta_5} = (7.424)^{1/2} (74)^{1.75} = 5087.15$

$\beta_1 = \beta_3 + 0.000005 \beta_2 - 0.00189 \beta_2 f^{-1.1}$

$= \beta_3 + 0.02543575 - 0.9761967601 = 0.5632876753$

$|E^*| = 100{,}000 \times 10^{B1}$

$= 365.84 \times 10^3 = \underline{3.66 \times 10^5 \text{ psi}}$

BOOK ANSWER: 3.8×10^5 psi

Q NO. 7.7 :-

Given data:

$\epsilon_t = 0.00015 \quad N_f = ??$

Data from question #7.5 :-

$PI = 1.441$

$\sigma_m = 2 \times 10^9 \text{ N/m}^2$

$V_b = 15.37\%$

Using AI eqn/. in For const. stress test :-

Eqn/. 7.32 :

$$0.00015 = [36.43 \times 1.441 - 1.82 (1.441)(15.37) + 9.71 (15.37) - 24.04] \times 10^{-6} \left(\frac{2 \times 10^9}{5 \times 10^9}\right)^{-0.125} \left(\frac{N_f}{10^6}\right)^{-0.2}$$

~~$0.00015 = (137.59 \times 1.2925) \left(\frac{N_f}{10^6}\right)^{-0.2}$~~

$\Rightarrow$ ~~$\epsilon_t =$~~

$$0.00015 = (137.06) \times 10^{-6} (1.2925) \left(\frac{N_f}{10^6}\right)^{-0.2}$$

$\Rightarrow$ $N_f =$

Eqn/. 7.33 $\Rightarrow$

$$N_f = [0.0252 PI - 0.00126 PI (V_b) + 0.00673 V_b - 0.0167]^5 \epsilon_t^{-5} \sigma_m^{-1.4}$$

$$N_f = [0.0252(-1.441) - 0.00126(-1.441)(15.37) + 0.00673 \times 15.37 - 0.0167]^5 (0.00015)^{-5} \times \left(\frac{2\times10^9}{6.9\times10^3}\right)^{-1.4}$$

$N_f = 8.754 \times 10^5$ repetitions. (Book answer: 8.8×10^8)

For constant strain test.

Eqn/. 7.35 =>

$$N_f = [0.17PI - 0.0085PI(V_b) + 0.0454V_b - 0.112]^5 \epsilon_t^{-5} \sigma_m^{-1.8}$$

$$= [0.17(-1.441) - 0.0085(-1.441)(15.37) + 0.0454(15.37) - 0.112]^5 (0.00015)^{-5} \left(\frac{2\times10^9}{6.9\times10^3}\right)^{-1.8}$$

$N_f = 8.04 \times 10^7$ repitition. (Book answer: 8.1×10^7)

Using graph (Fig. 7.26) in Values are verified from graph

Using $PI = -1.441$ (For Book constt. stress & strain)

$V_b = 15.37$

$\sigma_m = 2\times10^9$ N/m²

& $\epsilon_t = 1.5\times10^{-4}$

Qno. 7.8:-

Given data: $\epsilon_t = 0.00015$

$N_f = ??$

From Qno. 7.6 data req. is:

$V_a = 4.81\%$

$V_b = 15.37\%$

$|E^*| = 3.8 \times 10^5$ psi

Eqn/. 7.36 $\Rightarrow$

$$N_f = 0.00432 C \epsilon_t^{-3.291} |E^*|^{-0.854}$$

Eqn/. 7.37(a) $\Rightarrow$

$$C = 10^M$$

Eqn/. 7.37(b) $\Rightarrow$

$$M = 4.84\left(\frac{V_b}{V_a + V_b} - 0.69\right)$$

$$= 4.84\left(\frac{15.37}{5.81 + 15.37} - 0.69\right)$$

$$M = 0.17271$$

$$\Rightarrow C = 10^M = 1.48838$$

$$\Rightarrow N_f = 0.00432 (1.4884) (0.00015)^{-3.291} (3.8 \times 10^5)^{-0.854}$$

$$N_f = 4.24 \times 10^5$$

(Book answer: 6.4×10^5)

Using eqn/. 7.38:

$$N_f = 0.0796\, \epsilon_t^{-3.291}\, |E^*|^{-0.854}$$

$$N_f = 5.25 \times 10^6$$